

ABSTRACT FOR CA 893216

L1 ANSWER 1 OF 1 WPIX (C) 2003 THOMSON DERWENT

AN 1972-13222T [09] WPIX

TI Thermoplastics tubing extrusion - with increased cooling by internal air flow.

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Thermoplastics material, specif. polyethylene, ethylene alkene-1 copolymer, polyamide, polypropylene or polyolefin, is extruded as a tube over the surface of an internal mandrel from a die. A gaseous medium is passed into the area between the tube and mandrel to maintain the tube clear of the mandrel surface and a second fluid medium is evenly distributed against the exterior surface of the tubing at the point at which it first comes closer than 0.005 in. to the mandrel surface. The velocity of flow of the medium is 100 to 400 ft/sec.

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**SUBSTITUTE**

***REPLACEMENT***

**SECTION is not Present**

***Cette Section est Absente***

**SUBSTITUTE**  
***REEMPLACEMENT***

**SECTION is not Present**

***Cette Section est Absente***

The present invention relates to the manufacture of thermoplastic film and in particular to a process and apparatus for obtaining improved cooling of the thermoplastic film during the manufacturing process.

In the manufacture of film from thermoplastic materials it is usual to extrude the thermoplastic material from a die which can be either a slot or an annulus.

Often a very high cooling rate is desirable at the zone of solidification in order to obtain good optical and mechanical properties. Heretofore, a variety of techniques have been employed to obtain fast cooling with the annular die method. These methods include external air cooling rings, cold inner mandrels and combinations thereof.

In the past, the combination of an inner mandrel and an external air ring has given moderately good cooling rates. Attempts to increase these rates by increasing the air flow through the air ring caused fluttering in the semi-molten film making the process unstable and not acceptable.

Lowering water temperature in the internal mandrel cooler has only a secondary effect in increasing quench rate and attempts to increase markedly the quench rate in this manner have not been successful.

Another limitation in these processes is that the film is not cooled simultaneously from the two sides of the film, but rather first one side of the film is cooled sharply and then the other side is cooled.

It is therefore an object of the present invention to provide a process for obtaining higher quench rates which have heretofore not been obtainable with the tubular film process.

It is another object to provide a process which permits precise location of the solidification zone of the film.

It is a further object of the present invention to provide a process for cooling both surfaces of a tubular film



substantially simultaneously.

Accordingly, the present invention provides a process which comprises:

extruding a thermoplastic material which is suitable for dry extrusion in the form of molten tubing; advancing said tubing past the surface of a cooled internal mandrel;

passing a first gaseous medium into the region between the surface of said mandrel and said tubing at a rate sufficient to maintain said tubing in proximity to but out of contact with the surface of said mandrel;

10 directing an evenly distributed flow of a second gaseous medium against the exterior surface of said tubing at the point at which said tubing first comes closer than 0.005 inch of the surface of said mandrel, the velocity of flow of said second gaseous medium being from about 100 to 400 feet per second.

20 The present invention also provides an apparatus comprising:

an extruder with associated annular die adapted to extrude thermoplastic material in the form of tubing; a substantially rigid mandrel mounted coaxially with said die and adapted to receive said tubing around said mandrel;

means for advancing the tubing past said mandrel;

means for supplying a first gaseous medium within said tubing to sustain said tubing in proximity to but out of contact with said mandrel;

30 an air ring mounted about said tubing, said air ring having an annular outlet adapted to direct a flow

of a second gaseous medium against the outside surface of said tubing at the point at which said tubing first comes closer than 0.005 inch of the surface of said mandrel, the velocity of flow of said second gaseous medium from the lips of said air ring being from about 100 to 400 feet per second.

These and other objects of the present invention will become evident from the more detailed description set forth below, it being understood that such more detailed description 10 is given by way of illustration and explanation only and not by way of limitation, since various changes may be made by those skilled in the art without departing from the scope or spirit of the present invention.

In connection with that more detailed description:

Figure 1 is a sketch of a conventional blown film process.

Figure 2 is a sketch of a blown film process employing an internal mandrel.

Figure 3 is a sketch of the blown film process of the 20 present invention.

A conventional air ring blown film process is illustrated in Figure 1 in which a tube of molten thermoplastic material 11 is extruded from annular die 12. The tube is inflated by internal air pressure and is cooled by a cooling flow of air being directed about the circumference of the blown tube by an air cooler 13. In such an apparatus the velocity of the flow of cooling air is usually about 75 ft. per second. The solidification zone or frost line of the film is generally indicated at 14.

30 The internal mandrel process is illustrated in Figure 2. In such a process an internal mandrel 21 is mounted coaxially with an annular die 22 and is cooled usually by a circulating liquid cooling medium. The molten thermoplastic material is

extruded in the form of a tube 23 from the annular die 22. A gaseous medium such as air is injected into the space between the internal mandrel and the annular die at a rate and under sufficient pressure to maintain the tube in close proximity to the internal mandrel but out of contact with the surface of the mandrel.

It is customary to use an air ring 24 in conjunction with the internal mandrel 21 as an auxiliary cooling means. Under these conditions the air ring is stationed so that the 10 air strikes the film bubble fairly close to the die in a manner similar to the conventional air ring process and with air velocities equal to or slightly lower than those customarily used in the air ring process. The location of the resultant first line is generally indicated at 25.

The process of the present invention is illustrated in Figure 3. This process is somewhat similar to the internal mandrel process discussed above. The thermoplastic material is extruded from an annular die 31 in the form of a tube 32. The tube is then drawn upwardly away from the die and over an 20 internal mandrel 33. A gaseous medium such as air is passed into the region between the surface of the mandrel 33 and the tube 32 at a rate sufficient to maintain the tubing in close proximity to, but out of contact with the surface of the mandrel. An air ring 34 is also employed, however it is located in a completely different location to that heretofore used and much higher velocities of air flow (above 100 feet per second) are required to obtain the advantages of the present invention. The resultant frost line is indicated generally at 35.

The process of the present invention comprises direct-  
30 ing the flow of air from the air ring so that the air strikes the film where it first approaches closer than 0.005 in. to the surface of the internal mandrel. The proximity of the

mandrel to the film stabilizes the molten film so that very high velocities of air can be employed without the signs of flutter which has heretofore been a major problem with high air flows. With this type of configuration and with the high air velocities which are achieved, cooling rates are reached which have heretofore been obtainable only by passing the film into liquid media. With this process, heat transfer is achieved from both surfaces of the film substantially simultaneously.

10 The present process has a major advantage over the direct liquid cooling process in that the film is not wetted and no subsequent drying step is required.

The process of the present invention has the following major advantages over prior art processes:

- (1) The film can be cooled at a higher rate which gives film of higher impact strength and better optical properties.
- (2) The film cooling zone can be precisely located so that there is an additional degree of control over the stretching or orientation of the film.
- 20 (3) Several variations of films can be produced from one resin so that the requirements of different types of resins are minimized.

As the process is employed, the film is first operated in the normal manner with the internal mandrel, then as the air velocity is increased, the process goes through a region of less stable operation. As the air velocity is increased further, however, the process becomes more stable.

As some polymeric films solidify, there is a region of haziness which is known in the art as a "frost line". In an

30 internal mandrel process operated with a vertical axis, this frost line falls in a horizontal belt around the internal mandrel. In that the frost line represents cooling history of the

melt, this line around the mandrel exhibits peaks and valleys. These peaks and valleys represent a summation of both random and non-random components in the cooling history.

It is a characteristic of the process of this invention that the frost line is narrowed in belt width and also the distance from peak to valley is reduced. This is further illustration of the achievement of a higher cooling rate.

The cooling rates produced by this process are surprisingly high. It has been found that in polyolefin-type materials the density decrease of the film is a measure of the cooling rate history of the film. Ethylene-butene-1 copolymers exhibit the following density decreases:

|                             |             |
|-----------------------------|-------------|
| Normal cooling ring process | 0.003       |
| Internal mandrel process    | 0.006       |
| Chill roll process          | 0.007       |
| Water bath process          | 0.010-0.020 |

The two surface cooling process of the present invention typically gives decreases of 0.006 to 0.015 which are well into the range reached only by liquid quenching heretofore.

An example of the contribution of this process to film properties is shown in the following example for medium density ethylene-butene-1 copolymer.

|  | Internal Mandrel Process | Two-Surface Cooling Process of the Present Invention |
|--|--------------------------|--|
| Gloss - 20°                            | 110                      | 140  |
| Haze - %                               | 4.0                      | 2.8  |
| Resin Density                          | 0.935                    | 0.935  |
| Film Density                           | 0.929                    | 0.921  |
| Density Decrease                       | 0.006                    | 0.014  |
| Elmendorf Tear - MD                    | 40                       | 400  |
| TD                                     | 430                      | 500  |
| Dart Impact - F <sub>50</sub> (gm/mil) | 30                       | 47   |
| Air Velocity - fps                     | -                        | 175  |
| Air Impingement Angle - Degrees        | -                        | 60   |

The effect of the process on film properties from a lower density resin is shown in the following example:

|    | <u>Internal Mandrel Process</u>        | <u>Two-Surface Cooling Process of the Present Invention</u> |
|----|--|---|
| 10 | Gloss - 20°                            | 95  |
|    | Haze - %                               | 5   |
|    | Resin Density                          | 0.922   |
|    | Film Density                           | 0.917   |
|    | Density Decrease                       | 0.005   |
|    | Elmendorf Tear - MD                    | 100   |
|    | - TD                                   | 300   |
|    | Dart Impact - F <sub>50</sub> (gm/mil) | 75  |
|    | Air Velocity - fps                     | -   |
|    | Air Impingement Angle - Degrees        | 60  |

It is noteworthy that the changes of haze and gloss of 30% are quite significant both in a technical sense and a commercial sense. The improvement in dart impact strength of 20-30% is significant in the product.

The position of the air ring may be changed slightly within certain parameters and still obtain these improved film properties.

It has been found that the air ring must be located so that the annular jet from the air ring impinges on the thermoplastic film where the film is closer than 0.005 inch to the mandrel. The velocity of the air leaving the air ring is much higher than heretofore employed and preferably is in the range of from about 100 to 400 feet per second.

The air exits from the air ring between a pair of lips. The velocity referred to is the velocity in the lips or in the vena contracta as may be appropriate. This latter measurement would be used should the lands of the lips not be parallel.

The angle of the air flow as it strikes the thermoplastic film preferably should be between 25° and 95° measured from the direction of film travel. The radial distance between the lips of the air ring and the mandrel is preferably from about 1/8 inch to 1 inch.

Thermoplastic materials which may be used to advantage in the practice of the present invention are those thermoplastics which are suitable for dry extrusion and include:

polyethylene  
polyamide  
polypropylene  
polyolefin  
ethylene-alkene-1 copolymer.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A process which comprises:

extruding a thermoplastic material which is suitable for dry extrusion in the form of molten tubing; advancing said tubing past the surface of a cooled internal mandrel;

passing a first gaseous medium into the region between the surface of said mandrel and said tubing at a rate sufficient to maintain said tubing in proximity to but out of contact with the surface of said mandrel;

directing an evenly distributed flow of a second gaseous medium against the exterior surface of said tubing at the point at which said tubing first comes closer than 0.005 inch of the surface of said mandrel, the velocity of flow of said second gaseous medium being from about 100 to 400 feet per second.

2. The process as claimed in Claim 1 in which said thermoplastic material is selected from a list comprising:

polyethylene  
ethylene alkene-1 copolymer  
polyamide  
polypropylene  
polyolefin

3. The process as claimed in Claim 1 in which said thermoplastic material is a polyolefin and the density of the film is from 0.006 to 0.015 below that of the polyolefin material being fed to the extruder.

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4. The process as claimed in Claims 1 or 2 in which the direction of flow of said gaseous medium is at an angle of from about 25° to 95° from the direction of travel of said tubing.

5. The process as claimed in Claims 1, 2 or 3 in which said second gaseous medium is air.



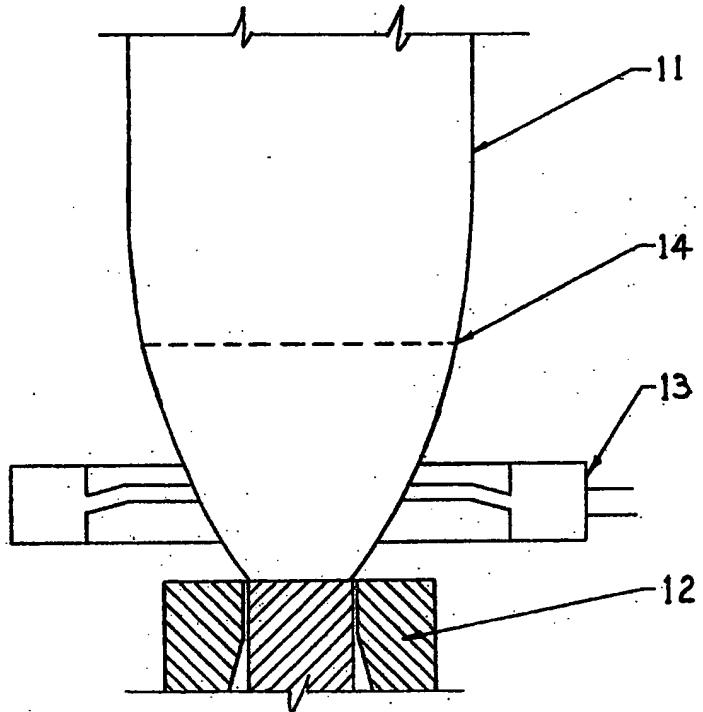


FIG. 1

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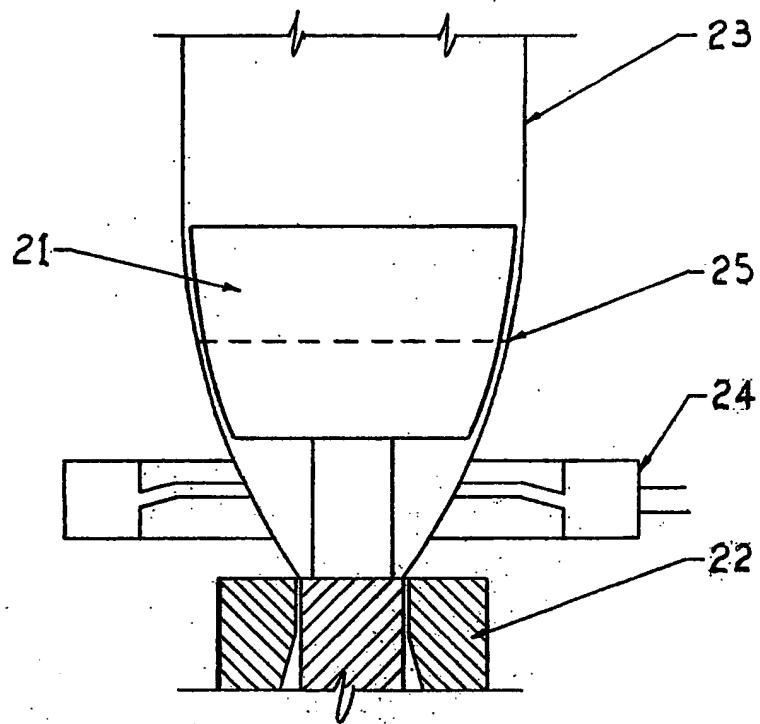


FIG. 2

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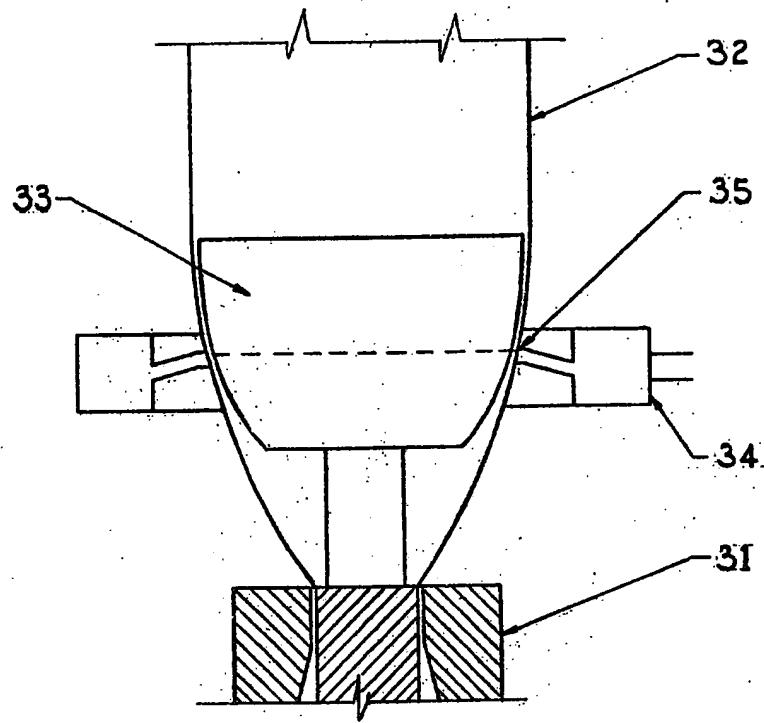


FIG. 3

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